University of California
Science & Technology Review
Lawrence Livermore National Laboratory
P.O. Box 808, L-664
Livermore, California 94551

Nonprofit Org.
U. S. Postage
PAID
Albuquerque, NM
Permit No. 853

Lawrence Livermore National Laboratory

2002 ANNUAL REPORT

Printed on recycled paper.

Managed by the University of California for the Department of Energy's National Nuclear Security Administration.

INSIDE THIS ANNUAL REPORT

About the Cover

In April 2002, groundbreaking ceremonies were held for two national security facilities: the International Security Research Facility (cover and p. 23) and the Terascale Simulation Facility (pp. 10–11), housing the world's most powerful computer.

About the Laboratory

Lawrence Livermore National Laboratory was founded in 1952 as a nuclear weapons research facility. The Laboratory has been managed since its inception by the University of California (UC), first for the Atomic Energy Commission and now for the National Nuclear Security Administration (NNSA) within the U.S. Department of Energy (DOE). Through its long association with the University of California, the Laboratory has been able to recruit a world-class workforce and establish an atmosphere of intellectual freedom and innovation, both of which are essential to sustained scientific and technical excellence. As an NNSA national laboratory with about 8,000 employees, Livermore has an essential and compelling core mission in national security and the capabilities to solve difficult, important problems.

DIRECTOR'S STATEMENT

Michael R. Anastasio

"Making History, Making a Difference" was the theme of the 50th anniversary of Lawrence Livermore National Laboratory, which we celebrated in 2002. Born as a branch of the University of California's Radiation Laboratory, Livermore has been applying leading-edge science and technology to help meet the country's most pressing national security needs for half a century. In addition to celebrating past successes, the anniversary year was a time for reaffirming what we are as a Laboratory and examining future prospects.

What we are and our exciting future are evident in this annual report, which summarizes significant accomplishments in 2002 and the direction of major research programs at the Laboratory. I am very proud of Livermore's outstanding staff, and one of my top priorities since becoming director is to ensure the continuing vitality of the workforce. Exceptional people make Livermore an exceptional national laboratory. Our scientific and technological breakthroughs are meeting important mission objectives, and Laboratory business services and operations are being carried out in an efficient, safe, secure, and environmentally responsible manner.

As part of the Department of Energy's National Nuclear Security Administration, we are a key contributor to the Stockpile Stewardship Program to sustain a safe and effective nuclear deterrent. We are also engaged in efforts to counter the proliferation of weapons of mass destruction and activities to strengthen homeland security. The unique research capabilities of the Laboratory to pursue these missions—and our multidisciplinary approach to problem solving—mean that our scientists and engineers are also able to respond to a wide range of national needs in energy and environment, biosciences, and basic sciences.

This annual report highlights only some of the Laboratory's fine work as well as the challenges and opportunities we face. With our commitment to national service and excellence in all of our activities, we have a bright future with much to accomplish as we work to make the world more secure and a better place in which to live.

"Making History, Making a Difference"

Event Week in September 2002 marked the high point of the Laboratory's year-long celebration of 50 years, "Making History, Making a Difference." Panel discussions, special conferences, and ceremonies provided opportunities to reflect on Livermore's past contributions, current research activities, and prospects for the future. The festivities concluded with a weekend open house for Laboratory employees and retirees together with their families and guests.

Fittingly, Event Week began with recollections from a panel of six men and women who were among the first employees when operations started at the Livermore site in 1952. Later in the week, audiences learned more about Livermore's past—as well as future challenges—from a panel of former Laboratory directors. Science Day, an annual event to celebrate the Laboratory's outstanding research, also occurred during Event Week. With "Innovative Science and Technology—Our Heritage, Our Future" as its theme, Science Day featured presentations in four topic areas aligned with the Laboratory's missions: astrophysics, fusion energy, bioscience, and atmospheric science. Livermore researchers have made—and continue to make—important contributions in these areas.

Distinguished visitors came to the Laboratory to participate in a conference, sponsored by the Laboratory's Center for Global Security Research, on the science and technology for national security over the next 50 years. The conference culminated in a panel discussion, chaired by former Secretary of Defense William Perry.

Former astronaut and U.S. Senator John Glenn was welcomed with a standing ovation before his stirring talk for employees. He then participated with Laboratory staff and members of local communities in a time-capsule dedication ceremony.

Also during Event Week, the Laboratory received many citations and gifts from officials of local communities, the State of California and its legislature, research partners and colleagues from around the world, and sponsors of Livermore's work. The Laboratory was especially honored by the gracious remarks of General John Gordon, representing the White House; Ambassador Linton Brooks, representing NNSA and DOE; Admiral James Ellis, Jr., Commander of the U.S. Strategic Command; Representative Ellen Tauscher (by video); and University of California President Richard Atkinson.

Special publications and other events throughout the year contributed employees' reflections about the Laboratory's history and continuing contributions to the nation. In particular, several series of lectures about the evolution of Laboratory programs were held during "Then and Now Week" in June 2002. Commemorative publications, which highlight accomplishments and the stories of current and former staff members, are available at Livermore's Website, together with a timeline of the Laboratory's history.

1

2

3

4

Numbered photos:
(1) Former Laboratory directors John S. Foster, Jr., and John Nuckolls;
(2) University of California President Richard Atkinson honoring former Laboratory director Michael May;
(3) NNSA Administrator Ambassador Linton Brooks (left side of table, center) at a working lunch; (4) (left to right) Secretary of Energy Spencer Abraham honoring Laboratory co-founder Edward Teller, with director Michael Anastasio.

Nuclear Weapons Stockpile Stewardship

Lawrence Livermore National Laboratory was established in 1952 to help ensure national security through the design, development, and stewardship of nuclear weapons. National security continues to be the Laboratory's defining responsibility. Livermore is one of the three national security laboratories that support the National Nuclear Security Administration (NNSA) within the Department of Energy (DOE).

Livermore plays a prominent role in NNSA's Stockpile Stewardship Program for maintaining the safety and reliability of the nation's nuclear weapons. The Stockpile Stewardship Program integrates the activities of the U.S. nuclear weapons complex, which includes Livermore, Los Alamos, and Sandia national laboratories as well as four production sites and the Nevada Test Site. It is an extraordinarily demanding program. As the nuclear weapons in the stockpile continue to age, Laboratory scientists and engineers are challenged to ensure their performance and refurbish them as necessary without conducting nuclear tests.

Working with the other NNSA laboratories, Livermore is attending to the immediate needs of the stockpile through assessments and actions based on a combination of laboratory experiments and computer simulations of nuclear weapon performance. In addition, the Laboratory is acquiring more powerful experimental and computational tools to address the challenging issues that will arise as the nation's nuclear weapons stockpile continues to age. These vastly improved scientific capabilities will be used by experienced nuclear weapons designers to train and evaluate the skills of the next generation of stockpile stewards, who will rely on the new tools.

Engineering test stand in support of the W87 Life-Extension Program.

Certifying Stockpile Safety and Reliability

Livermore is a key participant in formal review processes and assessments of weapon safety, security, and reliability. In 2002, the seventh cycle of annual certification of the stockpile for the President was completed. Now called the Annual Assessment Review, the formal process is based on the technical evaluations made by the laboratories and on advice from the three laboratory directors, the commander of the U.S. Strategic Command, and the Nuclear Weapons Council. To prepare for this process, Laboratory scientists and engineers collect, review, and integrate all available information about each stockpile weapons system, including physics, engineering, chemistry, and materials science data. This work is subjected to rigorous, in-depth intralaboratory review and to expert external review, including the formal use of red teams.

For the Annual Assessment Review—and the formal certification of refurbished warheads—weapons experts depend on an extensive range of aboveground testing, vastly improved simulation capabilities, and the historical nuclear test database. Livermore and Los Alamos are also developing and beginning to apply a rigorous set of quantitative standards as the basis for formal certification actions and setting programmatic priorities. The methodology—quantification of margins and uncertainties (QMU)—is analogous to the use of engineering safety factors in designing and building a bridge.

E. O. Lawrence Award for Bruce Goodwin

Bruce Goodwin, a Laboratory physicist and currently associate director for Defense and Nuclear Technologies, was awarded an E. O. Lawrence Award in 2002. “I came up with some theories for the equations of state for plutonium under extreme conditions derived from peculiarities I saw in nuclear test data,” Goodwin said of his work. “I was flying in the face of 40 years of research, and the critics said it couldn’t be true.” However, Goodwin’s theories proved true, and the work helped pave the way for the Stockpile Stewardship Program and its emphasis on developing a much better understanding of the fundamental science underlying nuclear weapons performance through theory, modeling, and experiments.

Weapon Surveillance to Include Pit Inspections at Livermore

The Laboratory conducts a wide range of stockpile surveillance activities to assess the condition of Livermore-designed weapons in the stockpile and to better understand the effects of aging on weapons. These surveillance activities now include evaluating the pits in the primaries of Livermore-designed weapons. Livermore is the design laboratory for four weapon systems in the stockpile: the W87 and W62 ICBM warheads, the B83 bomb, and the W84 cruise missile.

Previously, these pit surveillance activities were carried out at Los Alamos. Transfer of the responsibility better balances the workload between the two laboratories and takes advantage of improved surveillance technologies developed at Livermore. In particular, surveillance will include the use of computed tomography to reconstruct three-dimensional radiographic images of pits. The technique is similar to medical tomography but uses much higher energy x rays so that small features can be resolved. In the future, this new tool may reduce the number of pits that have to be destroyed as part of the surveillance program.

To prepare for pit surveillance, the Laboratory installed new equipment for pit inspections in the Plutonium Facility and developed surveillance procedures. NNSA also conducted an in-depth review to qualify the program. In FY 2002, the Laboratory logged its first “scorable” pit surveillance evaluation, and the program is now fully operational.

Life Extension of the W87 ICBM and W80 Cruise Missile Warheads

Livermore's W87 Life-Extension Program, begun in late 1994, continues to meet all of its major milestones. Refurbishment of the W87 ICBM warhead, the design with the most modern safety features in the stockpile, extends the lifetime of the weapon to beyond 2025. With the final unit scheduled for completion in 2004, refurbished W87 warheads are being delivered to the Air Force after assembly at the Pantex Plant. The Laboratory developed the refurbishment design and is now collaborating with the production plants to ensure the quality of the W87 refurbishment work while maintaining the targeted production rate.

Lawrence Livermore and Sandia–California national laboratories have also assumed responsibility for the W80 Life Extension Program. The W80, designed by Los Alamos, is currently deployed in air-launched and sea-launched cruise missiles. Substantial test activities were initiated in 2002 in support of a schedule that calls for the first production unit of the refurbished warheads in FY 2007.

Experiments to Understand Nuclear Weapon Performance

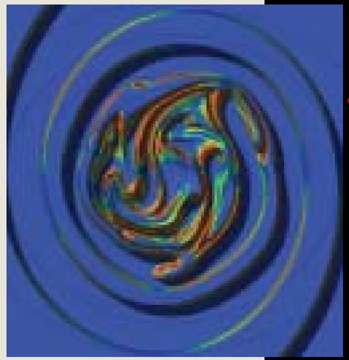
In 2002, researchers successfully carried out the first hydrodynamic experiments in the Contained Firing Facility (at left) at Site 300, the Laboratory's experimental test area 24 kilometers southeast of the main site. In these critically important experiments for stockpile stewardship, scientists study the performance of mock weapon primary pits as the pits are imploded by high explosives. With construction completed in 2001, the Contained Firing Facility houses the Laboratory's most modern facility for conducting these types of tests. In a firing chamber designed to withstand repetitive tests using up to 60 kilograms of high explosives, the facility minimizes the noise, blast pressures, and generation of hazardous materials resulting from experiments.

Many other types of experiments are also being conducted to understand the performance of weapon components and materials. For example, in 2002, researchers fired the ninth and final subcritical experiment in the Oboe series. These highly instrumented tests, conducted in an underground alcove at the Nevada Test Site, provide data on the behavior of plutonium when it is strongly shocked and how that behavior differs depending on the age of the material or manufacturing processes used. Because plutonium has such complex material properties and is so important for weapon performance, Livermore has acquired and is using unique laboratory equipment, such as the most powerful transmission electron microscope in the NNSA complex, for metallurgical and chemical examination of plutonium.

3D Weapons Physics Simulations

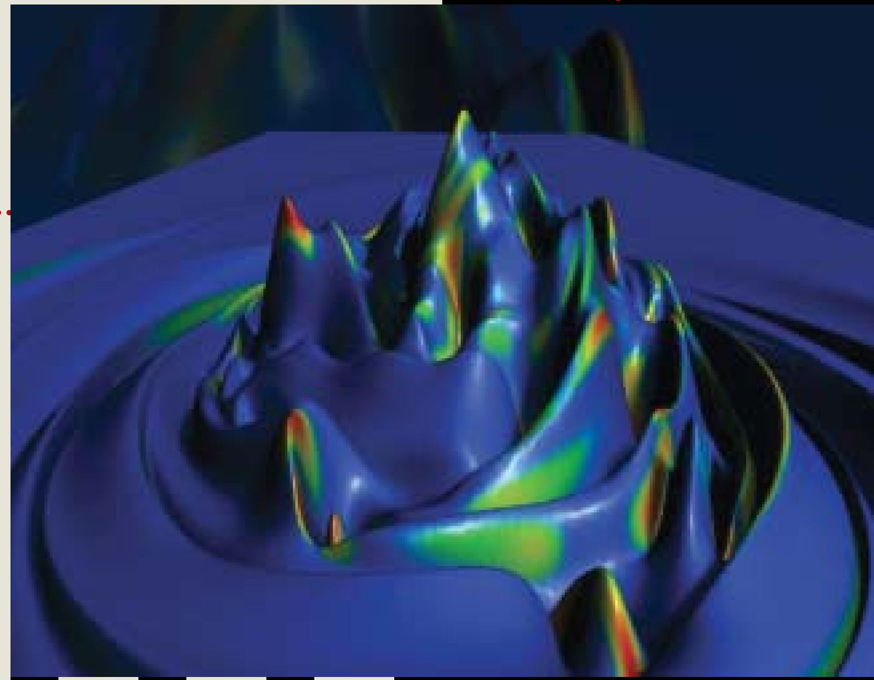
Increasingly sophisticated physics simulations are made possible by the arrival at the Laboratory of successively more powerful computers as part of the NNSA's Advanced Simulation and Computing (ASCI) program. The computer models being run on Livermore's ASCI White supercomputer, capable of more than 12 trillion operations per second (teraops), range from simulations of quantum molecular activity and multiscale models of material properties to three-dimensional (3D) simulations of full weapon performance.

Teams of scientists from Livermore and Los Alamos each have used ASCI White to complete 3D simulations of a complete warhead explosion. Three-dimensional simulation is critically important because nuclear explosion phenomena—such as high-explosive detonation, hydrodynamics, and radiation transport—are not always symmetric because of aging and manufacturing variations. The size and scale of ASCI White allowed the two laboratories to perform calculations with a level of spatial resolution and a degree of realism in the physics models that had not previously been possible.



Livermore's calculation, for example, ran a total of 43 days on 1,024 processors of the ASCI White computer and produced tens of trillions of bytes of data. Sandia has also used ASCI White to perform extremely large, sophisticated structural dynamics calculations. Both Sandia and Los Alamos performed their calculations remotely from New Mexico. The speed, large memory, and stability of ASCI White were essential elements contributing to the successful series of calculations.

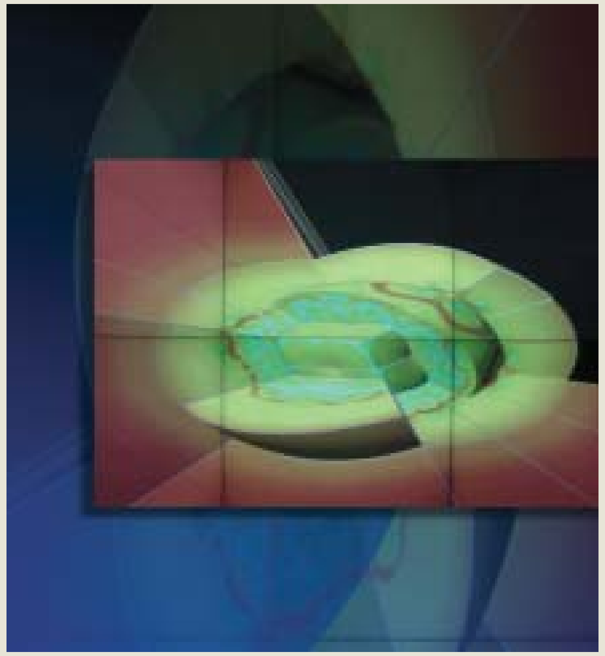
One challenge for researchers is analyzing the huge datasets that are generated in simulations. As part of ASCI's Visual Interactive Environment for Weapons Simulation (VIEWS) effort, advanced tools are being developed for visually exploring data, such as that generated in a calculation of the turbulent mixing of fluids of different density (shown).



A Detailed Model of High-Explosive Detonation

Laboratory researchers have developed an advanced computer simulation model to better understand the details of the detonation process for high explosives. The phenomena are complex because of the extreme conditions that occur during detonation—temperatures to 3,500 kelvins, pressures to 500,000 times Earth's atmosphere, and billionth-of-a-second timescales. In addition, explosives are highly heterogeneous materials consisting of small crystallites of an explosive molecule bonded together with a plastic binder. More than 100 billion of these crystallites, called grains, are irregularly packed into a cubic inch of explosive.

Livermore's grain-scale simulations have modeled the interaction of the detonation shock wave in a small cube of HMX high explosive. The cube contained 100,000 grains and realistically included voids, binder material, and intragranular defects, which greatly affect the detonation process. In addition to developing the model, Livermore researchers conducted sophisticated experiments to gather data characterizing the molecular behavior at high temperature and pressure of the explosive materials and detonation products. The results of these grain-scale simulations, run on the ASCI White supercomputer, will provide the basis for more realistic models for the detonation process in larger-scale simulations of the performance of real weapon systems.



The World's Most Powerful Computer

In November 2002, DOE Secretary Spencer Abraham announced that International Business Machines (IBM) Corporation had won a $290-million, multiyear contract to build the two fastest supercomputers in the world—ASCI Purple and Blue Gene/L—both to be sited at Livermore. ASCI Purple, a 100-teraops (trillion operations per second) machine, will enable 3D simulations with high-fidelity physics models of the performance of a full nuclear weapon system. The supercomputer will be powered by 12,544 microprocessors in 196 individual computers interconnected via an extremely high-bandwidth, superfast data highway. The system will also have 50 terabytes (trillion bytes) of memory, which is 400,000 times more capacity than the average desktop computer and two petabytes (quadrillion bytes) of disk storage, the content of approximately one billion books.

In addition, the Laboratory and NNSA are working with IBM on a scalable "ultracomputer" called BlueGene/L. When completed, BlueGene/L will have a peak performance of 360 teraops using 130,000 processors. It will be capable of performing an important subset of computational problems—those that can be easily divided to run on many thousands of processors.

This expansion of Livermore's computing power has required construction of the Terascale Simulation Facility (TSF), a $92-million construction project launched with a groundbreaking ceremony in April 2002. The TSF will encompass approximately 253,000 square feet, including 48,000 square feet of raised computer floor for the high levels of power and cooling. Work on the facility is proceeding rapidly. One of two machine rooms will be completed in 2004 in time for the arrival of ASCI Purple.

The TSF will also include an Advanced Simulation Laboratory for the development of the data assessment hardware and software to analyze the extremely large data sets produced by ASCI calculations. Offices there will house approximately 288 staff members in secure and open work areas.

“Early Light” at the National Ignition Facility

In December 2002, the National Ignition Facility (NIF) project reached a major milestone when the first four of 192 laser beams were activated and generated more than 43 kilojoules of infrared light (photos this page). The following month, the first shot was fired in which laser light—frequency converted from infrared to ultraviolet—reached the target chamber. Achievement of “early light” at NIF marks the beginning of an important transition for NIF from a construction project to an experimental facility.

NIF is a cornerstone of the Stockpile Stewardship Program. The 192-beam laser facility, when completed, will be the world’s most energetic laser, generating 1.8 megajoules of ultraviolet light. Many of the fundamental physics processes of thermonuclear detonation will, for the first time, become accessible for laboratory study and analyses. By firing its laser beams in unison and focusing its energy on a marble-size target for a few billionths of a second, NIF will generate the temperatures and pressures needed to conduct experiments to validate weapons-physics computer codes and address important issues of stockpile stewardship. Experiments on NIF will evaluate the feasibility of inertial fusion energy, a long-standing program goal within DOE for energy security. In addition, NIF will also allow laboratory studies of astrophysics and materials under conditions similar to those found in stars.

The early light shots successfully demonstrated all of the systems in NIF needed to produce and direct energetic laser beams to the target chamber center, including laser components and optics, the laser beampath and supporting utilities, the power conditioning system, diagnostics, alignment, and computer controls. With just the first four of 192 laser beams functioning, NIF is fast approaching the energy capability of the Laboratory’s now-decommissioned Nova laser, which previously was the largest laser system in the world. An experimental program will soon begin using the first four laser beams, and NIF’s capabilities will grow as more beams are brought online.

Early light was made possible in 2002 by the major progress achieved by the NIF project team. Overall, the NIF project was more than two-thirds complete by year’s end. The beampath infrastructure in Laser Bay 2 (96 beams, including the four lasers brought into operation) was completed in May, and the utilities required for the first laser beams were installed. In addition, the 10-meter-diameter target chamber was aligned in the target bay. Both the beam enclosures to transport the first laser beams and the supporting diagnostics systems were also installed. In the Optics Assembly Building, which contains Class 10,000 through Class 100 clean-room facilities, more than 120 line replaceable units for the first four beams—optical components including mirrors, lenses, polarizers, windows, and crystals—were assembled and tested before being mounted in NIF.

The NIF project reached another significant milestone with the accomplishment of two years (2.6 million hours) of work on the site without a lost workday accident. In December 2002, the NIF team received its second National Safety Council Perfect Year Award. In December 2001, the NIF team was awarded its first Perfect Year Award in recognition of the project’s first million hours without a lost-time accident.

Reducing the Threat of Weapons of Mass Destruction

The acquisition and potential use of nuclear, chemical, or biological weapons (so-called weapons of mass destruction, or WMD) by countries or groups hostile to the United States pose grave threats to national security. Lawrence Livermore applies its expertise in nuclear weapons to the challenge of nuclear threat reduction. Because the dangers of proliferation are not limited to nuclear weapons, Livermore leverages its extensive resources in the life and physical sciences to develop capabilities for countering the proliferation and use of chemical and biological weapons.

The attacks of September 11, 2001, followed by the anthrax mailings, revealed the vulnerability of the U.S. to terrorism. The Laboratory was able to respond effectively and broadly to those attacks because it had been actively addressing the threat of WMD terrorism for many years.

A hallmark of Livermore's threat reduction work is its integrated approach to the complex and interconnected problems of WMD proliferation and terrorism. It addresses the full spectrum of the threat—from preventing proliferation at its source, to detecting and reversing proliferant activities, to responding to the threatened use or actual use of such weapons, to avoiding surprise regarding the WMD capabilities of others.

Some of Livermore's work is directed at strengthening the technological base for those agencies with operational responsibility for implementing and monitoring arms control and proliferation prevention agreements. Nuclear nonproliferation efforts include cooperative U.S.–Russian programs to secure at-risk nuclear materials, dispose of excess highly enriched uranium and plutonium, and assist in creating self-sustaining nonweapons jobs for displaced Russian weapons workers.

Other activities are directed at understanding foreign weapons programs, identifying and characterizing proliferation-related activities, and detecting and mitigating the use of WMD against the U.S. Livermore researchers work closely with the intelligence, law enforcement, emergency response, and public health communities to develop technologies, systems, and operational capabilities that meet end users' needs and function in real-world settings.

The search for survivors at the World Trade Center using a Laboratory-developed detector.

Homeland Security Organization Created

At ceremonies in December 2002 that were widely attended by the press and local dignitaries, Director Michael Anastasio announced the creation of a Homeland Security Organization (HSO) to provide the interface between the Laboratory and the U.S. Department of Homeland Security and to ensure that the full range of the Laboratory's capabilities is available to support the Department. The new Department is tasked with reducing the nation's vulnerability to terrorism, preventing terrorist attacks within the U.S., and mitigating damage and speeding recovery should an attack occur.

HSO draws on the many scientific and technical resources at Livermore to provide a multilayered defense against catastrophic terrorism. These efforts integrate threat, vulnerability, and risk assessments with the development of advanced technologies, field-tested prototypes, and operational capabilities. Tools and technologies are developed in partnership with end users to ensure they meet the real-world needs of the federal, state, and local entities with operational responsibility for homeland security.

HSO supports six program thrusts that map onto the organizational structure of the Department of Homeland Security: nuclear and radiological countermeasures, chemical and biological countermeasures, systems analysis and studies, intelligence analysis and infrastructure protection, border and transportation security, and emergency preparedness and response. Initially, HSO is responsible for the Laboratory activities that were explicitly transferred from the Department of Energy to the Department of Homeland Security. HSO's responsibilities will evolve as the Laboratory's relationship with the new Department matures.

Penrose Albright, from the new Department of Homeland Security, spoke at the Laboratory in December 2002.

A Tribute to 9/11

On the first anniversary of the September 11 attacks, a commemorative event was held at the Laboratory's main auditorium, attended by more than 300 employees who directly contributed to the nation's response. Televised for the entire Laboratory staff, the ceremony paid tribute to those who lost their lives. It also honored the Livermore employees called to military service or deployed to assist in homeland security and counterterrorism efforts. After the attacks in 2001, the Laboratory's nuclear incident response teams were put on alert, the Threat Assessment Center went to 24/7 operation, analysts flew to Washington to support the U.S. intelligence community, and prototype instruments were taken out of laboratories and deployed in the field to help with search activities in New York and with biodefense at critical sites around the nation.

New Tools to Enhance Homeland Security

Also announced in December 2002 were two new technologies to help defend against WMD terrorism. The Analytic Conflict and Tactical Simulation (ACATS) is a spin-off of Livermore's Joint Conflict and Tactical Simulation (JCATS), which the military uses for training, analysis, mission planning, and support of actual military operations. ACATS applies JCATS' cutting-edge simulation capabilities to the scenarios that may take place in an urban setting, from the spread of a chemical or biological agent within and around buildings to the search for survivors in the rubble of a bombed building. As players and users provide input to the simulation in nearly real time, ACATS models emergency response operations. ACATS is designed for use by local, regional, and state agencies to help them prepare responses to terrorist attacks, natural disasters, and large-scale accidents.

The second new technology is the Homeland Operational Planning System (HOPS). Livermore developed HOPS in partnership with the California National Guard, with funding from the Department of Defense. HOPS is a Web-based information system that models buildings, stadiums, convention centers, landmarks, and other potential terrorist targets and helps in assessing vulnerabilities and preparing emergency response plans. HOPS can link to the National Atmospheric Release Advisory Center, operated by Livermore, to rapidly obtain assessments of the dispersal and effects of chemical, biological, or radiological attacks. In the past two years, HOPS has supported the Los Angeles County Sheriff's Department in planning for the Democratic National Convention and the California National Guard in assuring security for the 2002 World Series.

BASIS Deployment at the Olympics

Lawrence Livermore and Los Alamos national laboratories jointly developed the Biological Aerosol Sentry and Information System (BASIS) that was deployed at the 2002 Winter Olympic Games in Salt Lake City, Utah, and at several other locations around the country. BASIS uses a network of distributed air sampling units located in and around potential target sites. The samples are then retrieved and brought to a field laboratory for analysis. To ensure that BASIS supports real-world operational needs, Livermore developers worked closely with the federal, state, and local public health agencies responsible for emergency response and medical operations in the event of a bioattack.

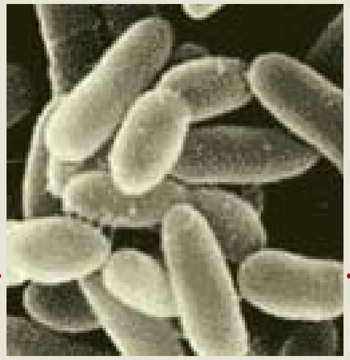
The heart of the BASIS field laboratory is the Cepheid Smart Cycler, which is based on advanced (miniaturized, real-time) polymerase chain reaction (PCR) technology developed at and licensed from Livermore. This technology reduces the time for detecting a bioagent release from days or weeks to hours. Miniaturized PCR technology is also used in Livermore's Handheld Advanced Nucleic Acid Analyzer (HANAA), the first truly portable, battery-powered biodetector. HANAA, which can provide results in 30 minutes or less, is being commercialized by the Environmental Technologies Group of Smiths Industries.

Several advanced biodetection concepts are under development. The goal of these instruments is to provide autonomous, rapid, and highly multiplexed detection and analysis of biological pathogens. For example, the Autonomous Pathogen Detector System (APDS) provides stand-alone, automated, continuous monitoring and identification of biological agents. This past year, Livermore researchers demonstrated an APDS prototype capable of autonomous multiplex detection with analysis times of approximately a minute for each measurement. Work is under way on even more advanced concepts for highly multiplexed detection (hundreds of simultaneous assays) of viruses, toxins, spores, and vegetative bacteria.

DNA Signatures for Homeland Security and Public Health

PCR instruments such as HANAA and APDS work by amplifying biological signatures—unique short stretches of DNA—for each pathogen of concern. By combining computational analyses and laboratory screening, Livermore researchers have developed "gold standard" signatures for most of the top pathogens of concern for bioterrorism, including *Yersinia pestis* (plague), *Bacillus anthracis* (anthrax), and many others. Identifying such DNA signatures is challenging because pathogens are notorious for sharing useful genes. If a DNA signature is not truly unique to its organism, some false samples will test positive. Conversely, if the signature DNA is not present in all the different strains of the target organism, false negatives will result. The signatures are validated in collaboration with the Centers for Disease Control and Prevention (CDC). In addition to their use in biological-agent sensor systems, the signatures are distributed by the CDC to the nationwide Laboratory Response Network that analyzes disease outbreaks.

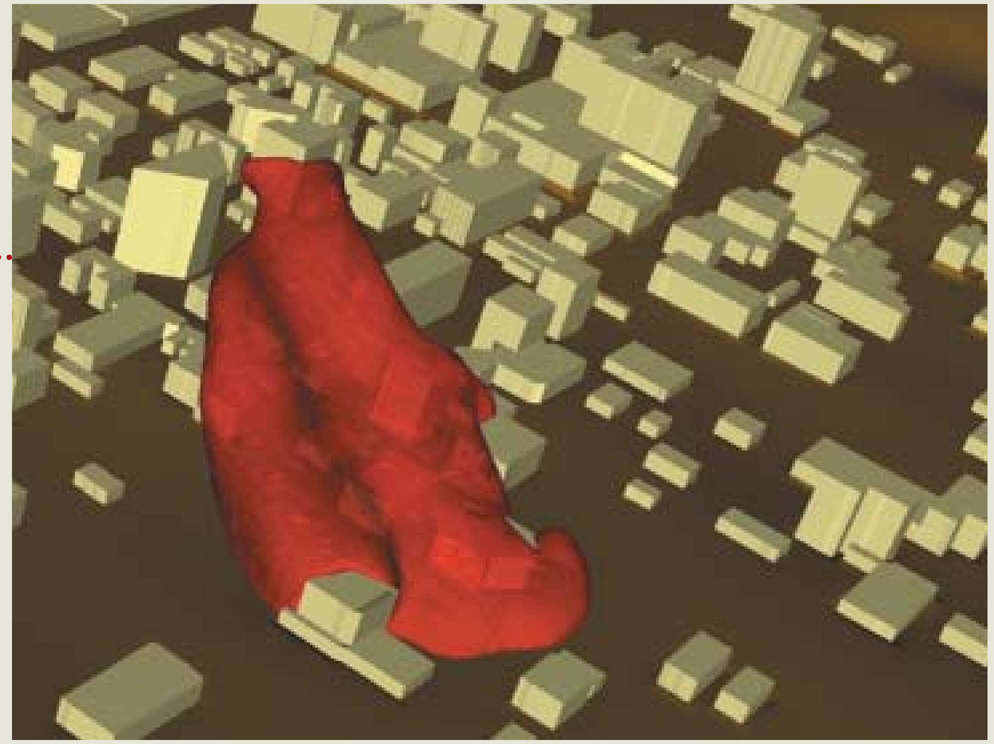
The technologies developed by the Laboratory and others to fight bioterrorism can also be used to detect naturally occurring pathogens in food, plants, and animals. Working with UC Davis and the State of California, Livermore researchers have developed tests for foot-and-mouth disease, exotic Newcastle disease (which is threatening California's poultry industry), West Nile Virus, Campylobacter (a bacterium present in undercooked chicken), and different types of Salmonella (a bacterium that can be found in eggs, juice, fruit, or vegetables). Using these DNA signatures and PCR-based detection instruments, test results can be obtained in less than an hour.



Enhanced Capabilities to Track Chemical and Biological Releases

In 2002, Livermore began working with agencies in the Seattle area to evaluate an approach for improving local emergency response capabilities. In this pilot project, local emergency management centers can link to the National Atmospheric Release Advisory Center (NARAC). NARAC is a national emergency response service for real-time assessment of incidents involving radiological, chemical, biological, or natural hazardous material. The goal of the Local Integration of NARAC with Cities (LINC) program is to provide a unified tool for city, county, state, and federal agencies to use in emergency planning and response.

NARAC can map the probable atmospheric spread of contamination in time for an emergency manager to decide whether protective actions are necessary. NARAC can also be used to evaluate specific scenarios for emergency response planning, such as optimizing the siting of bioaerosol samplers or determining evacuation routes. Since 1979, NARAC has responded to more than 160 alerts, accidents, and disasters and has supported more than 850 exercises. Recent efforts by NARAC researchers have focused on improving the simulation of biological or chemical releases in an urban environment, including the three-dimensional effects of buildings that block and channel winds.



Improved Radiation Detectors and Cargo Container Inspection

Transportation and immigration authorities have a pressing need for radiation detection technologies that can discriminate weak signals from complex backgrounds in the field. Laboratory researchers have developed handheld gamma-ray detectors that offer precise energy resolution and good sensitivity. One design (shown below) includes an identification system with the detector. The other was the product of a collaborative effort by researchers at Lawrence Livermore and Lawrence Berkeley national laboratories. Both detectors use a germanium crystal diode cooled to about 100 kelvins to achieve their excellent performance. Their small size is a result of innovative approaches to cooling the crystal without use of liquid nitrogen or a large refrigeration unit. Much more portable than other high-resolution germanium detectors, these instruments are suitable for deployment at border crossings, airports, and other locations.

A significant threat to homeland security is the possibility that a nuclear device or nuclear materials could be smuggled into the U.S. inside air, maritime, rail, or truck cargo containers. In 2002, Livermore established a national test bed for cargo container experiments, and researchers began testing the capabilities of commercially available and prototype instruments to detect nuclear materials inside loaded containers. Among the participants in the evaluation project were personnel from the U.S. Coast Guard and Bureau of Customs and Border Protection. This facility is unique in that measurements can be made on actual weapons materials inside actual shipping containers loaded with realistic cargoes.

Forensic Capabilities Support Homeland Security

Livermore's Forensic Science Center has expertise and instrumentation for complete chemical and isotopic analysis of inorganic, organic, or mixed materials such as chemical warfare agents, explosives, and illegal drugs. The center also develops microanalytical forensic techniques, field instruments, and sample-collection technologies as well as new methods for detecting and characterizing the sources of weapons materials. These capabilities are supporting Laboratory initiatives in nuclear- and chemical-weapons forensics. Livermore and Los Alamos play central roles in the Domestic Nuclear Event Attribution program, sponsored by the Defense Threat Reduction Agency. The program's objective is to enhance the nation's capabilities for determining the origin of a terrorist nuclear device and its materials.

Over the past two years, the Forensic Science Center successfully passed three rigorous proficiency tests to be certified by the Organisation for the Prohibition of Chemical Weapons (OPCW) as an analytical laboratory for chemical weapons challenge inspections. The OPCW is responsible for implementing the Chemical Weapons Convention, which outlaws the development, production, acquisition, stockpiling, and use of chemical weapons as well the transfer of chemical-weapons-related technologies. As an OPCW-accredited laboratory, Livermore will participate in analyzing samples acquired during challenge inspections of facilities of concern. OPCW designation validates Livermore's expertise in chemical analysis and detection and places the Laboratory's response capabilities at the forefront in the event of a chemical threat, terrorist or otherwise.

(at left) Eleanor and John Lawrence (son of Laboratory co-founder E. O. Lawrence) visit the Forensic Science Center.

Construction of the International Security Research Facility

In April 2002, ground was broken for the $24.6-million International Security Research Facility. The two-story, 64,000-square-foot building will house some 180 people, with space for offices, electronic archiving, a flexible secure conference center, an information-processing hub, an imagery exploitation laboratory, a communications vault, and an emergency operations center. This new facility will enable the Laboratory's intelligence analysts to take advantage of the digital revolution in the intelligence business and will accommodate expanding programmatic needs for secure work space. Occupancy is scheduled for late 2004.

(left to right) Melanie Elder and Bruce Tarter of Livermore, Representative Ellen Tauscher, UC Vice President John McTague, and Rhys Williams of the Department of Energy.

Meeting Enduring National Needs

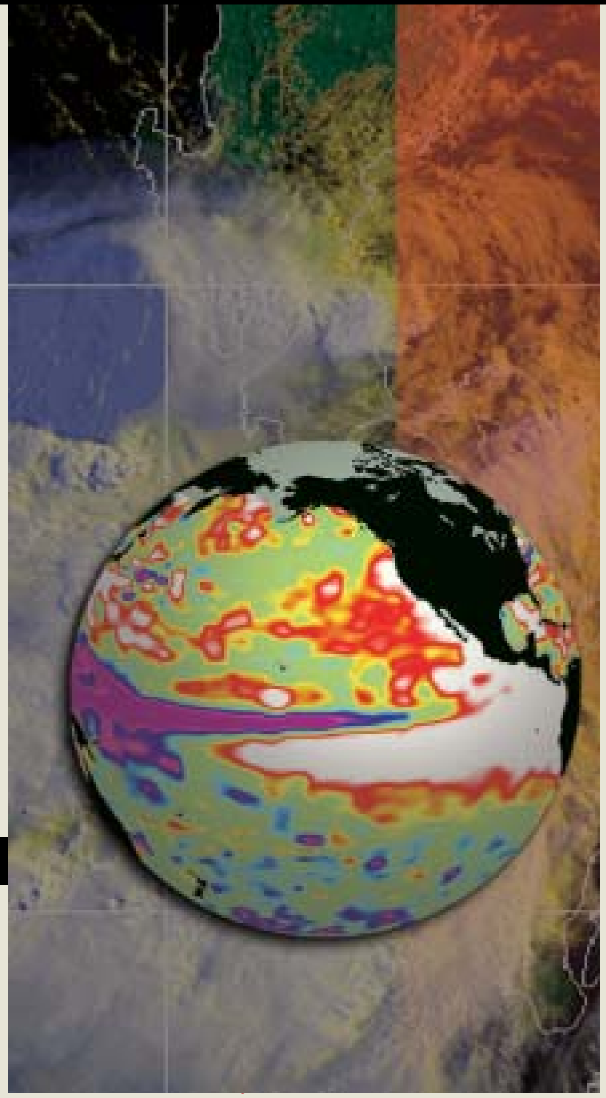
As part of its overarching national security mission, the Department of Energy pursues research and development in a variety of areas that are of enduring importance to the nation. In selected areas where the Laboratory can make valuable contributions, Livermore researchers support DOE mission priorities in energy and environment, bioscience, and fundamental science and applied technology. These activities make use of the Laboratory's multidisciplinary approach to problem solving, wide-ranging capabilities, specialized research facilities, and unique areas of expertise. Challenges are sought that reinforce the Laboratory's national security mission and have the potential for high-payoff results.

Long-term research is needed to help provide the nation with abundant, reliable energy together with a clean environment. Livermore's energy and environmental programs contribute to providing the scientific and technological basis for secure, sustainable, and clean energy resources for the U.S. and to reducing risks to the environment.

Bioscience research at Livermore enhances the nation's health and security. Leveraging the Laboratory's physical science, computing, and engineering capabilities, projects focus on molecular biology, genetics, computational biology, biotechnology, and health-care research. Research efforts are directed at understanding causes and mechanisms of ill health, developing biodefense capabilities, improving disease prevention, and lowering health-care costs.

In addition, initiatives are pursued in fundamental science and applied technology that reinforce strong research areas at the Laboratory. Many projects, sponsored by DOE's Office of Science and other customers, take advantage of the unique research capabilities and facilities at Livermore. Other work, supported by Laboratory Directed Research and Development funding, extends the Laboratory's capabilities in anticipation of new mission requirements.

Livermore's National Atmospheric Release Advisory Center (NARAC) provides real-time emergency predictions for hazardous substance releases.



The Climate Outlook: A Warming Trend

Computer simulations and data gathering by Livermore researchers are contributing to worldwide efforts to better understand the history of Earth's climate, changes due to human activities, and methods for mitigating the consequences.

One puzzle about climate change was addressed in a recent paper by Laboratory scientists and an international team: why satellite temperature measurements of the lower troposphere show little or no warming since such data collection began in 1979. Because these data, differing from other aspects of climate, have been used to support skepticism of global warming, the team decided to take a closer look. In their new study, sophisticated climate models separated the effects of recent major volcanic eruptions and El Niños from other causes of climate change. Remarkably, the results showed that large volcanic eruptions—El Chichón in 1982 and Mount Pinatubo in 1991—had a cooling effect on the lower troposphere that masked the overall warming trend shown in surface temperature data and brought about by human activities.

The natural variability of climate was the subject of a data-gathering trip in 2002 to the Gulf of Alaska by a team, including a Livermore scientist, sponsored by the National Oceanographic and Atmospheric Administration's Ocean Explorer Program. More than one ton of samples of seawater, coral, and sediment from the ocean floor was gathered by the Alvin submersible as deep as 3,800 meters. At Livermore's Center for Accelerator Mass Spectrometry, the isotopic profiles of the corals are being studied to better understand climate–ecosystem variability in the Gulf of Alaska over the last few hundred years. The sediment samples will tell a longer story—up to 250,000 years—at lower resolution.

Many other studies and collaborative research of climate change are ongoing, including completion of global climate simulations at the highest resolution yet performed (50 kilometers). In addition, computer studies are providing insights into the utility of injecting carbon dioxide deep in the ocean to sequester the greenhouse gas for centuries so that it does not contribute to global warming.

E. O. Lawrence Award for Ben Santer

In 2002, Ben Santer, a physicist in the Laboratory's Program for Climate Model Diagnosis and Intercomparison, received an E. O. Lawrence Award. The award cited "his seminal and continuing contributions to our understanding of the effects of human activities and natural phenomena on the Earth's climate system." Among his many contributions to the field, Santer was lead author of the critically important Chapter 8 of the *1995 Second Assessment Report of the Intergovernmental Panel on Climate Change*. The report concluded that "the balance of evidence suggests a discernable human influence on global climate"—a conclusion that has grown stronger as a result of continuing research on climate change. In 1998, Santer received a MacArthur Foundation "genius award."

Fuel Cells for Portable Electronics and Efficient, Clean Power

Livermore's Center for Microtechnology Engineering has developed and demonstrated a prototype miniature fuel cell that may provide portable electric power for consumer electronics as well as for sensors for military and security applications. Using easy-to-store liquid fuels such as methanol, the thin-film fuel cell power module is lighter weight than rechargeable batteries and provides more than three times the operating time.

The power module incorporates a thin-film fuel cell and microfluidic fuel-processing components in a common package (photo at right). The patented design and method for making the fuel cells combine microcircuit processes, microfluidic components, and microelectrical-mechanical systems (MEMS) technology.

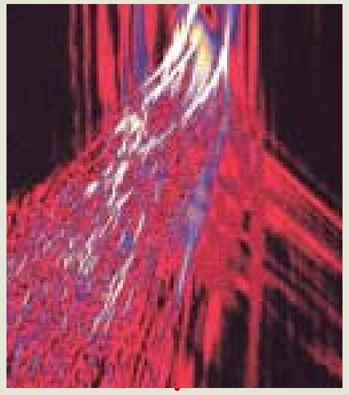
Livermore researchers are also improving the design of solid-oxide fuel cells, with the goal of making the technology an effective option for clean and efficient power generation for the 21st century. Solid-oxide fuel cells are particularly attractive because of their high efficiency. By applying materials science expertise, scientists are developing a very-high-power-density prototype that operates at a temperature low enough so that more affordable materials and manufacturing technologies can be used. A prototype modular fuel cell, consisting of a stack of three single cells, has been built and tested at the Laboratory. It achieved a power density of 1.05 watts per square centimeter at 800 degrees Celsius, a result for a stack of cells that is at least 50 percent higher than previously reported.

Materials Testing and Modeling for the Yucca Mountain Program

In February 2002, President Bush endorsed the DOE's recommendation to store high-level nuclear waste in an underground repository at Yucca Mountain, Nevada, and Congress subsequently provided its support for DOE's decision. For the Yucca Mountain Program, Livermore has played a major role in materials testing and performance modeling for the storage canister and system of engineered barriers surrounded by natural barriers to contain the radioactive waste. Laboratory researchers are now working to support major project milestones toward license application. In these efforts, significant emphasis has been placed on achieving high quality assurance.

At the Laboratory's Long-Term Corrosion Test Facility, researchers are conducting materials performance tests to confirm that the waste packages will maintain their integrity for thousands of years. Some 20,000 test specimens are currently being exposed or have been tested to expected conditions in vessels that simulate the bounding chemical and thermal conditions in the repository. In addition, new codes are being used to simulate the geologic evolution of the repository, predict the temperature evolution surrounding the buried waste, and explore the possible means by which water could enter the repository tunnels over geologic time periods.

Fusion Energy Science Progress on Many Fronts



In 2002, Laboratory researchers advanced fusion energy science through computational and experimental work on both inertial confinement fusion and magnetic fusion performed primarily for DOE's Office of Science. In the area of magnetic fusion energy, Livermore collaborates in experiments using the DIII-D Tokamak at General Atomics in San Diego and provides leadership in the development and use of computational models, such as UEDGE and BOUT, to study turbulence and other physical phenomena at the edge of the plasma (image at left). Recent BOUT calculations compare favorably with experimental data from the DIII-D and other tokamaks. Capabilities at Livermore can greatly contribute to U.S. participation in the International Thermonuclear Experimental Reactor (ITER) project.

In addition, Livermore is the site of the Sustained Spheromak Physics Experiment (SSPX), an alternative to the tokamak concept that may lead to lower-cost fusion reactors because of the spheromak's compact size and reduced complexity. In 2002, experimenters measured plasma temperatures greater than 300 electronvolts. The result is two times higher than temperatures attained at the beginning of the year and higher than previously reported measurements for any driven spheromak plasma.

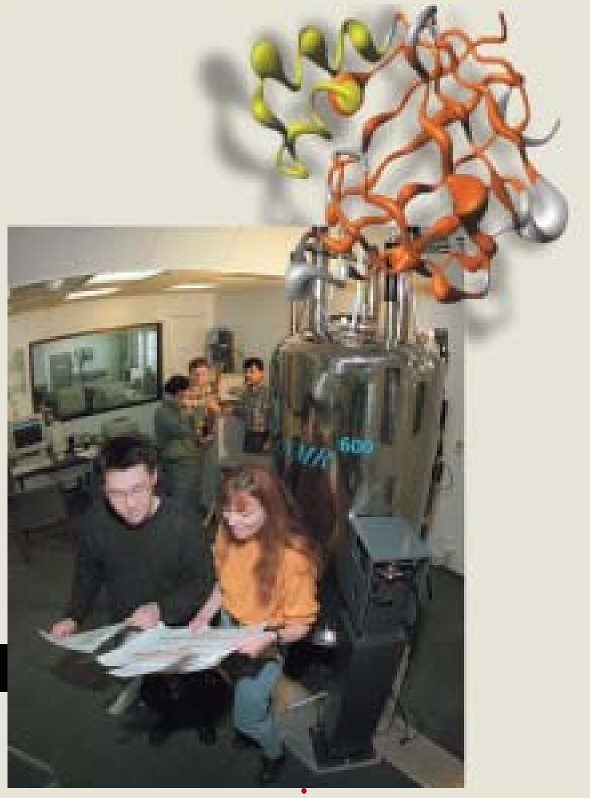
With the National Ignition Facility under construction, Livermore also provides international leadership in research in inertial confinement fusion. In collaboration with Lawrence Berkeley National Laboratory and others, Livermore researchers are investigating the concept of using a heavy-ion accelerator as the driver in an inertial fusion power plant. The effort reached a major milestone in 2002 with the dedication of Livermore's STS-500 (photo at left) and first experiments using the 500-kilovolt ion-source test stand. The STS-500 will be used for experiments addressing physics issues associated with the formation and behavior of heavy-ion beams.

Livermore's New Unclassified Supercomputer in the Top Five

To meet the growing needs of all of Livermore's programs for high-performance computing, the Laboratory acquired a new unclassified supercomputer, the Multiprogrammatic Capability Resource (MCR) machine, which complements the computing resources made available to the Stockpile Stewardship Program through NNSA's Advanced Simulation and Computing (ASCI) program. The MCR supercomputer was delivered during summer 2002 and became fully operational by October 31, when it was named the world's fifth fastest computer by Top 500, a supercomputing Website. The machine dramatically increases Livermore's unclassified computing capability. It is being used to support important projects in biology, materials science, lasers, and atmospheric science. Classified computing is accomplished on the Laboratory's more powerful ASCI White machine.

Using Linux cluster architecture, MCR provides 2,304 processors capable of performing 11.2 trillion calculations per second. Built by Linux NetworX and Quadrics, it is the first Linux-based supercomputer to be ranked in the top 10. At a cost of less than $14 million, MCR is a factor of 10 less expensive than the other top-ranked supercomputers. In the "operations per dollar" category, MCR ranks number one.

Experiments and Simulations to Predict Protein Structure



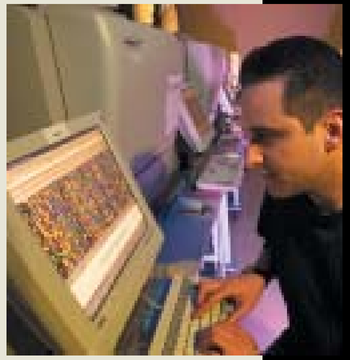
Researchers at the Laboratory are engaged in experimental and computational efforts to determine the structure of proteins. The three-dimensional structure of a protein offers clues as to its role in the body. This information can also be used to develop new diagnostic tools or therapies. Currently, structures are known for only a small percentage of the proteins that have been sequenced. Sequence data continues to accumulate at a rate that outpaces experimental data, which is gathered using x-ray crystallography and nuclear magnetic resonance spectroscopy. Methods of structure modeling and computational prediction are helping to close the information gap, for example, by extending the structural information to proteins within the same sequence family. Simulation tools are benefiting from dramatic increases in computer performance; however, fully predictive modeling tools have not yet been developed.

The Protein Structure Prediction Center at Livermore is coordinating two efforts for the sequencing community to help speed up the work. A critiquing process developed at the Laboratory called CASP (critical assessment of techniques for protein structure prediction) tests various prediction methods in advance of the experimental structures being released to the public. In addition, a related initiative, dubbed the "Ten Most Wanted," focuses modeling efforts on a small set of biologically important proteins whose structures are otherwise not expected to be determined experimentally in the near future.

Strides in Understanding the Function of Genes

In July 2002, an international consortium led by the Joint Genome Institute (JGI) reported work in *Science* magazine on draft sequencing, assembly, and analysis of the genome of the Japanese pufferfish, *Fugu rubripes*. Pufferfish have the smallest known genome among vertebrates, the group of animals with backbones that includes humans. By comparing the human and pufferfish genomes, researchers were able to predict the existence of nearly 1,000 previously unidentified human genes. Earlier, the JGI, which is operated by the three University of California–managed national laboratories, sequenced mouse DNA related to human chromosome 19 to compare the genes of the two species. Determining the existence and location of genes helps scientists to begin characterizing how genes are regulated and function in the human body.

Especially important now is discovering novel sequences that play a role in determining where and when genes are turned on or off, because understanding normal gene function is the first step in predicting disease mechanisms. Toward this longtime goal, Livermore scientists are using comparative sequence analysis, simultaneously examining DNA sequences from multiple organisms, to identify elements that are conserved over evolutionary time periods. Such conservation often signals that an individual sequence is important, perhaps because it is a gene or an element that regulates the expression of a gene. This approach has recently been used to identify potentially new regulatory pathways for gene expression and to suggest mechanisms by which genes can take on new functions.



A New Tool to Detect Genetic Variation and Cancers

The immense international research effort to map, sequence, and understand the human genome has led to the development of new tools for biological research. One new tool developed by a Livermore team can detect single damaged or missing DNA bases within individual cells, the smallest unit of genetic information, and thereby can significantly improve current methods of detecting cancer and other diseases. In 2002, the new technique, called in situ rolling circle amplification (IRCA), garnered one of the 100 awards presented annually by *R&D Magazine* to honor the most technically innovative products of the year.

IRCA is a fast and inexpensive method to precisely locate a damaged or abnormal gene that indicates the presence of or a tendency toward a particular disease, making IRCA ideal for analyzing tissue biopsies. In addition, IRCA provides answers in a couple hours, compared to a wait of several days required with tests using traditional methods.

Award-Winning Solid-State Laser Technologies

In 2002, two solid-state laser technologies developed at Livermore earned R&D 100 Awards. One winner was the solid-state heat-capacity laser (SSHCL), developed with industrial partners and sponsored by the U.S. Army Space and Missile Command. The refrigerator-size SSHCL can produce up to 13,000 watts in a single, high-quality beam with output pulse energies of more than 600 joules, making it the most powerful solid-state laser in the world. A 6-second shot of laser light from the system can bore a 1-centimeter-diameter hole in a 2-centimeter-thick plate of steel. In the past, this sort of fire power was available only from large gas or chemical laser systems. A larger laser that will produce 100,000 watts in a single beam is being developed. It will open up a range of applications for industrial materials processing and military defense.

The power of the SSHCL would be considerably higher if the flashlamp-pumped lasers in the system were replaced with a new diode-pumped solid-state laser technology, which also won an R&D 100 Award in 2002. This Livermore-developed technology, called SiMM (silicon monolithic microchannel), relies on photolithography and high-production etching techniques to produce thousands of miniscule, 30-micrometer-wide channels in silicon substrates. Water flowing through these microchannels cools the laser diode bars that are attached to the silicon, allowing the diodes to perform at higher average power than previously possible. To date, Livermore has fabricated arrays that measure just 10 by 18 centimeters and produce up to 45 kilowatts of power.

High-Data-Rate Laser Communication Demonstrated

Laser communication technology took a major step forward in 2002 with successful demonstration of an open-air link between the Laboratory and Mount Diablo, 28 kilometers apart. The Secure Air–Optic Transport and Routing Network, or SATRN, is a Laboratory Directed Research and Development project to meet the need for timely, secure, and economically practical data transmissions that exceed the capacity of radiofrequency and microwave systems. The challenge is to demonstrate an extended-range laser communication link with a high availability rate and a low bit-error rate. In 2002, the SATRN team collected data at a rate of 10 gigabits per second (contrasted with 270 megabits using radiofrequency links) without creating an information bottleneck by using four 2.5-gigabit-per-second channels operating at slightly different wavelengths. Livermore-developed adaptive optics systems, their use already proven in astronomical observatories, are key to the enhanced laser communication capability. The SATRN team is extending the concept's viability through efforts to increase the data rate to 40 to 100 gigabits per second and improve operability in varying weather conditions.

Adaptive Optics for Exploring the Solar System and Improving Vision

The Laboratory is at the forefront of developing adaptive-optics systems, which sense and correct aberrations, for a variety of applications. Livermore researchers are key partners in the Center for Adaptive Optics, a National Science Foundation Science and Technology Center, located at the University of California at Santa Cruz. In June 2002, Laboratory staff who are founding members of the center participated in the dedication of the center's new building.

In astronomy, Livermore-developed adaptive optics at the Keck Observatory in Hawaii (left) are enabling astronomers to minimize the blurring effects of Earth's atmosphere, producing images with unprecedented detail and resolution. They are now able to measure the shapes and sizes of asteroids, monitor weather patterns on Titan and Neptune, and image the faint rings of Neptune and Uranus (image below). A 20-watt dye laser built at the Laboratory has been installed on the Keck telescope to produce an artificial guide star, which allows adaptive-optic corrections to be made when viewing an object anywhere in the sky.

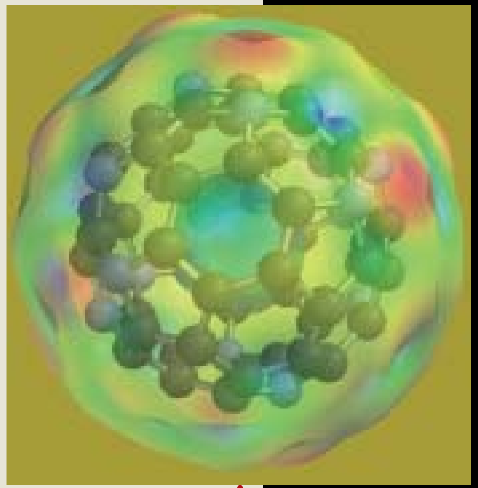
Researchers are also developing adaptive optics to study the human eye and to help in the early detection of eye disease. This new generation of prototype clinical adaptive-optics system is based on compact MEMS (microelectrical-mechanical systems) technology being developed at Livermore in partnership with industry and academia. These new systems will be used to study the limits of human visual acuity, which will guide improvements in contact lenses and laser refractive surgery.

Osmium Is Stiffer than Diamonds

The stiffest materials also tend to be the hardest ones. But in the case of diamonds and osmium, the former is still the harder even though the latter is stiffer. This surprising information was discovered by a Laboratory physicist who decided to study osmium because its stiffness had never been accurately measured. He crushed the osmium under 60 gigapascals of pressure in a diamond-anvil device and measured the resulting x-ray diffraction pattern to determine the spacing between osmium atoms. Osmium was found to have a bulk modulus—a measure of stiffness, or resistance to compression—of 462 gigapascals compared with 443 gigapascals for diamond.

A New Spin on Buckyballs

A high school student and a college student working at the Laboratory over the summer teamed up with a Livermore chemist to uncover an exciting new variant of a buckyball that includes nitrogen. The buckyball, or buckminsterfullerene, is a harder-than-diamond material consisting of 60 carbon atoms forming a molecule with a hollow core and perfect "soccer ball" symmetry. In analyzing the work of chemists who synthesized a fullerene material consisting of 48 carbon and 12 nitrogen atoms, the Livermore team found in its calculations a novel, more complex structure of these atoms that would be even more stable than the synthesized molecule.



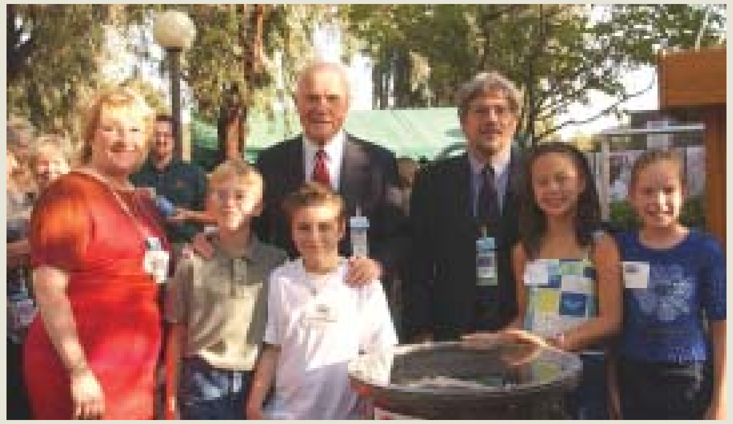
With the team's results published, buckyballs bounced back into science news. Scientists have been interested in synthesizing fullerenes using other elements such as nitrogen to fine-tune properties that do not exist in C_{60} and reduce the cost of producing nanostructured materials. The new $C_{48}N_{12}$ material is highly elastic, resilient, and hard, ideal for such applications as orthopedic implants. It also provides a basis for synthesizing other nitrogen-substituted fullerenes with novel structural, electronic, and conducting properties.

Shaping the Laboratory's Future

In 2002, Livermore's 50th anniversary events and publications celebrated numerous past accomplishments and a tradition of scientific and technical excellence. Current challenges and future prospects were also the focus of commemorative activities. The next half-century begins with a new director, Michael Anastasio, who was selected in June 2002. He is leading a Laboratory that is committed to meeting important programmatic responsibilities, seizing opportunities to address emerging national needs, and conducting operations in a safe, secure, and efficient manner.

Livermore's most valuable asset is its quality workforce, and one of the new director's top priorities is for the Laboratory to continue to attract an outstanding staff. Livermore strives for a workforce that is committed to excellence and reflects the diversity of California and the nation. The Laboratory seeks to provide a work environment in which all employees can contribute to the fullest and feel valued for their role.

Many 50th anniversary events involved the participation of not only employees—past and present—but also neighbors, research partners, and work sponsors who have shared in Livermore's successes. The Laboratory and its staff have grown as part of local communities, contributing to civic endeavors and a safe, clean environment, and as part of the University of California, contributing to its mission of education, research, and public service. Livermore is also a vibrant member of the international scientific community, partnering with other DOE and NNSA laboratories, universities, U.S. industry, and researchers around the world. For the nation, the Laboratory remains focused on ensuring national security and applying science and technology to the important problems of our time.



Finishing touches to the Laboratory's time capsule were added by astronaut and U.S. Senator John Glenn at ceremonies that included Laboratory employees and members of local communities.

New Director Takes on Challenges and Opportunities

Jay Solmonson, ANG Newspapers

New and former Laboratory directors Michael R. Anastasio (left) and C. Bruce Tarter.

In June 2002, Michael R. Anastasio was named the ninth Laboratory director by the University of California Board of Regents. Anastasio succeeds C. Bruce Tarter, who served as director for eight years while the Laboratory acquired vastly improved scientific capabilities for stockpile stewardship and greatly expanded programs to counter the proliferation of weapons of mass destruction.

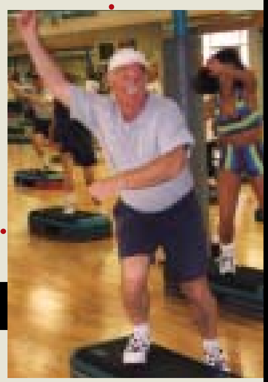
As Anastasio accepted the responsibility, he emphasized that employees are the "heart and soul" of the Laboratory. The new director set as one of his top priorities continuing to attract to the Laboratory the caliber of people who have sustained Livermore's scientific excellence over the years. Current challenges arise from Livermore's need to deliver on important programmatic milestones and meet high standards in operations. In his many meetings with Laboratory staff, Anastasio has been inspiring employees to meet those challenges and to seize opportunities to meet pressing national needs through advances in science and technology. Prominent in his message about the Laboratory, its culture, and its future is a succinct list of values to guide employees' actions and public expectations about Laboratory performance.

In conjunction with his focus to ensure the continuing vitality of the workforce, Anastasio has launched an in-depth review of the Laboratory's current science and technology investment strategy. The goal is to update it, particularly in light of evolving national security needs and significant opportunities to make great strides in science and technology. Research excellence as well as people underpin the Laboratory's programs and make Livermore an exciting place for young scientists, engineers, and support staff to grow their careers.

We Value

- Passion for Mission.
- Integrity and responsible stewardship of the public trust.
- Simultaneous excellence in science and technology, operations, and business practices.
- Balancing innovation with disciplined execution.
- Teamwork while preserving individual initiative.
- Intense competition of ideas with respect for individuals.
- Treating each other with dignity.
- A high-quality, motivated workforce with diverse ideas, skills, and backgrounds.
- Rewarding and recognizing performance.
- Commitment to the collective success of the Laboratory.

Improving the Workplace and Attention to Staff Needs



Ensuring the continuing vitality of the workforce is a high priority of Laboratory management. To better and more systematically understand the issues facing employees and to assess their views, the Laboratory conducted a formal survey of employees' opinions in June 2001.

Survey Action Teams were formed to recommend improvements in response to survey results, which detailed the needs of the Laboratory's increasingly diverse workforce. The teams finished their work in February 2002, and Laboratory senior management responded with improvements in various areas. A number of recommendations have been implemented, such as expanded work/life services, additional career development and training programs, and new flexible work schedule options. Plans in other areas are progressing and will be implemented in 2003, including improvements to the Laboratory's performance management system.

Providing Effective Management and Good Business Practices

Managed by the University of California (UC) for the DOE's National Nuclear Security Administration (NNSA), the Laboratory has been working closely with the University and NNSA to improve the performance-based management system under which Livermore and Los Alamos operate. Since their inceptions, Lawrence Livermore and Los Alamos (as well as Lawrence Berkeley) national laboratories have been part of UC. The University has provided the special environment and stability that have enabled the laboratories to make many remarkable scientific achievements and vital contributions to national security.

In 2002, the performance-based management assessment process was revamped to closely align the measured objectives with integrated mission performance, scientific and technical excellence, and operational effectiveness. The performance evaluation process will help ensure sharp focus on the most important elements of mission execution and reinforce efforts to further improve program integration between the two UC-managed national security laboratories.

In both scientific work and day-to-day operations, Laboratory employees expect to be accountable to high standards. However, recent events at Los Alamos have called into question the standards

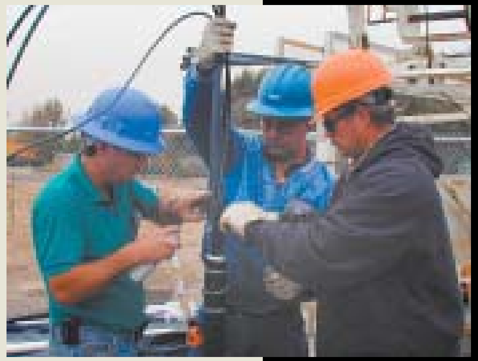
of business operations at the UC national laboratories. In response, Director Anastasio took actions to examine key areas of the Laboratory's operations, provide reassurance that business policies and practices are sound, and make improvements wherever necessary. Livermore has in place high expectations about staff performance, prudent business practices that include checks and balances, and effective training programs. In particular, in the areas of property management and purchase cards, the Laboratory implemented comprehensive accountability systems that have been carefully designed and tested before implementation.

Safe, Secure, and Environmentally Compliant Operations

Safe, secure, and environmentally compliant operations result from the dedicated efforts of all employees. DOE's Integrated Safety Management (ISM) System is in place at Livermore. In addition, in January 2002, NNSA and UC approved the Laboratory's plans for implementing an Integrated Safeguards and Security Management (ISSM) System. These systems help ensure that safety and security stay a top priority at the Laboratory. In the four years since ISM was implemented, the Laboratory has reduced annual illness and injury rates from 5.6 to 2.9 percent of full-time employees. This rate is less than rates reported by corporations doing similar work that have achieved Voluntary Protection Program status by the Occupational Safety and Health Administration. Two years and well over two million hours of work at the National Ignition Facility construction site without a lost workday accident (see p. 13) are evidence of effective safety management and performance.

Protection of sensitive information, nuclear materials, and other valuable assets at the Laboratory is critically important. An extensive security apparatus is in place, and continual adjustments and upgrades are made to address new threats and concerns. The Laboratory took swift actions to enhance security after the September 11 attacks and now operates routinely at heightened security. Additional security enhancements are being pursued. Protection employs the use of increasingly sophisticated measures in a cost-efficient manner. An example is Argus (photo at bottom left), a computerized system to provide reliable, high-level security. The system was designed and engineered at Livermore, where it has undergone many upgrades and enhancements since it was first installed in the mid-1990s. Argus is in operation at other DOE sites and is being installed at additional locations.

In 2002, the Laboratory successfully met 11 regulatory-required milestones for environmental cleanup activities at the main Livermore site and at Site 300, a remote experimental area located about 25 kilometers southeast of Livermore. Six major documents (including characterization reports, remedial designs, planning documents, and five-year reviews) were submitted and five soil-vapor and groundwater treatment units were completed on schedule. Ongoing efforts are yielding good progress in the cleanups. For instance, at Site 300, a plume of groundwater contaminated with volatile organic compounds (VOCs) at concentrations above drinking water standards once extended more than a kilometer offsite. This plume is now fully contained onsite, with only one Site 300 well showing VOC contamination slightly above these standards.

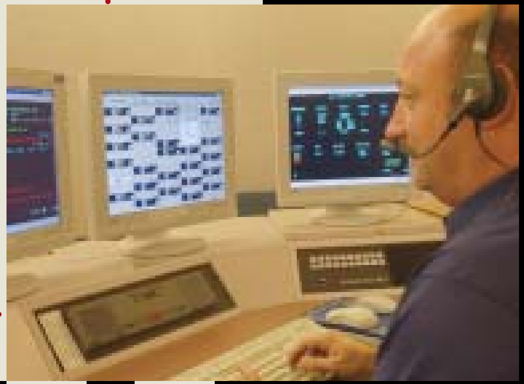


A Good Neighbor

The Laboratory's annual campaign to Help Others More Effectively (HOME) raised $1.4 million for Bay Area and Central Valley charitable organizations, the fifth straight year of record-setting contributions. HOME is one example of many outreach activities that include employee participation in community assistance and economic development organizations; environmental, health, and safety working groups; and educational outreach activities.

Educational programs include activities such as science fairs and student and teacher programs. An example is a two-day-long symposium held in September 2002 and attended by more than 120 middle school, high school, and community college science teachers. This was the third year for the Edward Teller Science and Technology Symposium, which is funded by the Laboratory and held in collaboration with the Edward Teller Education Center and UC Davis. Teachers tour state-of-the-art research facilities, talk informally with Laboratory scientists, and participate in hands-on workshops in biology, chemistry, radiation science, physics, optics, and environmental science.

Other cooperative efforts with local communities include the March 2002 agreement among a number of emergency response agencies to establish a consolidated fire dispatch system within Alameda County. Consolidation saves participants money, improves fire and emergency medical services, and enhances mutual aid. The new Consolidated Emergency Dispatch Center (bottom right photo) is located at the Laboratory. The Laboratory is also working closely with area mutual aid agencies and the cities in the Tri-Valley area to coordinate emergency planning efforts.



Part of the University of California

Many mutually beneficial collaborations between the Laboratory and UC campuses serve to strengthen research programs at Livermore and provide the campuses with access to the Laboratory's multidisciplinary capabilities and special research facilities. Examples include the Center for Biophotonics and the UC Davis Cancer Center, as well as the Laboratory's assistance in the establishment of UC Merced. The new university plans to have a close affiliation with Livermore, and research will be aligned with the Laboratory's in a number of areas. Laboratory staff members are helping to define scientific and engineering programs at the campus and are serving on search committees for senior staff.

The new Center for Biophotonics, located at UC Davis, will aid in the development of new technologies for a wide range of health-related applications, including imaging or selectively treating tumors, sequencing DNA, conducting biochemical studies, and identifying single biomolecules within cells. Dedicated in October 2002, the National Science Foundation–funded center was established in partnership with the Laboratory and eight other institutions. Livermore–UC Davis collaborations on biophotonics, for example, have led to the development of a portable pathogen detector, an instrument that analyzes a small blood or breath sample with light to quickly determine whether someone has been exposed to a pathogen in a bioterrorist attack or to a new infectious disease.

The UC Davis Cancer Center, established in partnership with the Laboratory, achieved National Cancer Center designation by the National Cancer Institute in July 2002. With this prestigious award comes a $1.2-million grant for each of the next three years. The center combines Livermore's science, medical, and engineering expertise with UC Davis's expertise in cancer research and clinical medicine. The work of the center encompasses six areas: molecular oncology, cancer biology in animals, cancer therapeutics, cancer etiology prevention and control, prostate cancer, and biomedical technology. Each area has 25 or more researchers involved, with participants from both Livermore and UC Davis.

Participating in the dedication of the Center for Biophotonics, a Livermore scientist shows a detector for measuring biological agents.

Broadly Benefiting the Nation and the State of California

Bioscience and health-care research and development at the Laboratory entails not only partnerships with other research institutions but also with U.S. industry. Many Livermore-developed technologies are undergoing commercialization. Their applications range from improved health care, such as the PEREGRINE system for planning radiation therapy, to a variety of tools for rapid detection of infectious diseases and biological agents.

In addition, other advanced technologies are being developed in partnership with industry. Most notable is work with an industrial consortium and Sandia and Lawrence Berkeley national laboratories to develop extreme ultraviolet lithography for fabricating the next generation of computer chips. One of the supporting technologies, a precise mirror-coating deposition system, earned Livermore and its industrial partner an R&D 100 Award in 2002 (photo, bottom right).

While focused on national needs, Livermore's research activities and capabilities also benefit California residents in special ways. For example, expertise at the Laboratory is helping state and local agencies on a wide range of water issues, from analyses of regional water supplies to development and application of new technologies for the characterization and cleanup of contaminated groundwater. Efforts have included an assessment of aquifer recharging for the Salton Sea, studies of long-term water recycling for Orange County, the characterization of MTBE in groundwater, and ongoing analyses (with the U.S. Geological Survey) of drinking water quality in California public water supplies. In addition, in support of the war on terrorism, the Laboratory works closely with response agencies to develop capabilities that meet real-world operational needs. Many of Livermore's first-responder and end-user partners are agencies within California.

Award-Winning Science and Technology

Each year, the scientific and technological accomplishments of Livermore employees are recognized outside the Laboratory by prizes, awards, and front-page publicity. Some of these achievements are described here. In addition, Laboratory scientists and engineers were responsible for 143 invention disclosures, 123 patent applications, 44 foreign patent applications, 102 issued U.S. patents, and 35 issued foreign patents in FY 2002.

Secretary of Energy Spencer Abraham announced two Livermore winners of the E. O. Lawrence Award, Bruce T. Goodwin and Benjamin D. Santer. Goodwin received the award in the national security category for his research on the complex dynamics of the fission triggers of thermonuclear weapons. Santer was honored in the environmental science and technology category for his contributions toward understanding the effects of human activities on Earth's climate.

Edward Teller received the Secretary's Gold Award, the Department of Energy's highest honor, for his outstanding contributions to science and the security of the nation. As Energy Secretary Spencer Abraham presented the award during a visit to the Laboratory, he said, "Dr. Teller is one of the giant figures of the 20th century, whose contributions to winning both World War II and the Cold War are immeasurable."

Former directors who were "present at the creation" of the Laboratory—Edward Teller, Harold Brown, John S. Foster, Jr., and Michael M. May—were presented University of California Presidential Medals by President Richard Atkinson. Herbert York had already received the award, which is the highest honor the president of the University can bestow.

R&D Magazine annually selects the 100 most technologically significant new products and processes, ones that are workable and beneficial to the real world. The Laboratory now has a total of 91 R&D 100 Awards, including the 2002 award winners:

• In situ rolling circle amplification (IRCA), a fast and inexpensive method to precisely locate a damaged or abnormal gene, indicating the presence or tendency toward a particular disease.

• The silicon monolithic microchannel (SiMM) cooling system, a module packaging technology for the smallest, most powerful, and least expensive laser-diode pumps ever.

• The solid-state heat-capacity laser (SSHCL), which produces up to 13,000 watts in a single, high-quality beam with energy of 600-plus joules, making it the most powerful solid-state laser in the world.

• The Production-Scale Thin-Film Coating Tool, developed by the Laboratory and Veeco Instruments Inc., a deposition system that opens the door to advanced high-volume manufacturing for the next generation of microprocessors.

• The transcutaneous electrical nerve stimulation (TENS) pain-management device, which inhibits the transmission of pain signals to the brain.

• Hierarchical Data Format 5 (HDF5), a file format and software library for managing, exchanging, and archiving large, complex types of data. The National Center for Supercomputing Applications at the University of Illinois (Urbana–Champaign) won the award, which was shared by developers at Livermore, Sandia, and Los Alamos national laboratories.

A Livermore technology licensee, Cepheid, also won an R&D 100 Award for GeneXpert, a fully automated gene analysis system.

Fred Milanovich and Cynthia Nitta were awarded the 2002 Edward Teller Fellowships by the director. Milanovich was cited Innovative detection capabilities. Nitta was recognized for her technical and programmatic contributions to the weapons program.

Chemist Leonard Gray received the 2002 Glenn T. Seaborg Actinide Separation Medal from the Advisory Board of Actinides Separation Conference to honor Gray's "outstanding accomplishment and meritorious achievement in actinide separations science."

Charles Carrigan, named a Fulbright Distinguished Scholar, was invited to perform research and teach for a year at Cambridge University's Department of Earth Sciences and St. Edmund's College.

Seven Livermore physicists were named fellows of the American Physical Society (APS):

• Tomás Díaz de la Rubia was elected for his contributions to multiscale modeling of materials and seminal research on defect processes in solids under irradiation or high-strain-rate conditions.

• Yu-Jiuan Chen was selected for her work in revolutionizing the achievable beam quality of linear induction accelerators and advancing the state of the art of flash x-ray technology.

• Forrest Rogers was nominated for his work in plasma physics, including the development and application of the ACTEX equation of state and OPAL code opacity models.

• Barbara Lasinski was cited for code development and application to the understanding of the physics of targets for high-power laser experiments.

• Otto "Nino" Landen was named for his work in picosecond laser–plasma interactions, advanced diagnostics, x-ray-driven inertial confinement fusion implosions, and time-dependent hohlraum symmetry control.

• Andrew McMahan was elected for his work in completing effective Hamiltonian parameters for copper oxides and phase transitions of materials under high pressure and the subsequent solution of the associated models.

• Donald Prosnitz was cited for his pioneering work in free-electron lasers, accomplishments in fundamental physics research, and contributions to society through research supporting national security and law-enforcement technologies.

Claire Max, founding director of Livermore's Institute of Geophysics and Planetary Physics, was named a fellow of the American Academy of Arts and Sciences. Edward Teller is the only other academy member from the Laboratory.

Two physicists nominated by the Laboratory, Mark Hermann (at Livermore) and Paul Ricker (at the University of Chicago), were among 60 winners of the Presidential Early Career Award for Scientists and Engineers, the nation's highest honor for professionals at the outset of their research careers.

Willy Moss was elected fellow of the Acoustical Society of America. He was honored for contributions to numerical modeling and single-bubble sonoluminescence.

Eight Weapons Recognition of Excellence Awards were presented by NNSA to 88 Laboratory employees. Of the eight awards, two individuals were honored: Randall L. Simpson, for leadership of high explosives development and analysis activities, and retiree William F. Scanlin, Jr., for contributions to advancing weapon primary design and archival work. Awards were also presented to the Burn Code Project Team, the W80 Baselining Study Team, the ASCI White Integration Team, the W62 Pit Surveillance Team, and Livermore employees who were part of the trilaboratory Capability Computing Services Support Team and the Isentropic Compression Experiments Team.

Craig F. Smith was elected fellow of the American Association for the Advancement of Science, for distinguished contributions to the advancement of nuclear science and technology.

Laboratory physicist Kennedy Reed was named the 2003 recipient of the American Physical Society's John Wheatley Award. Kennedy's award was given for multifaceted contributions to the promotion of physics research and education in Africa.

The Council of Energy Resource Tribes (CERT) presented the 2002 American Indian Spirit Award to Laboratory Executive Officer Ron Cochran and the Laboratory for "continued dedication and commitment to Native American education and leadership."

Mimi Alford received the Aegis Award for producing "A Journey Through Time. . . The History of Engineering at LLNL." The Aegis is a national award that recognizes excellence in video and film production among nonbroadcast organizations, such as corporations, government, and universities.

Abbie Warrick received an International SEMATECH Corporate Excellence Award. The award recognizes exceptional performance, achievement, and innovation in contributing to the semiconductor industry.

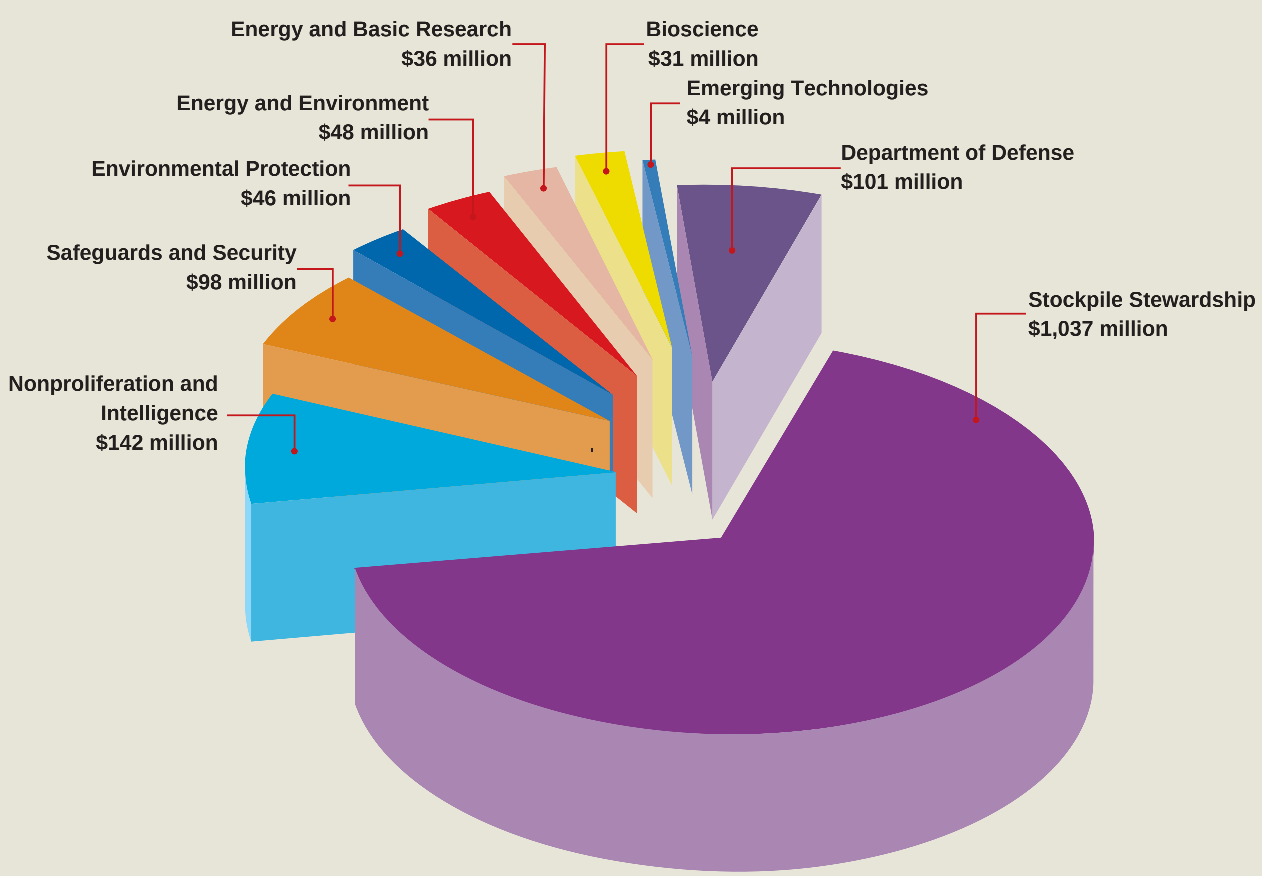
Valerie Roberts, area integration manager of infrastructure for the National Ignition Facility, was named Outstanding Woman in Construction, an award cosponsored by Arizona State University and the Greater Phoenix Chapter of the National Association of Women in Construction.

Laboratory Budget

Most of Livermore's $1.54-billion budget for FY 2002 was designated for research and development activities in program areas supporting the Department of Energy's missions.

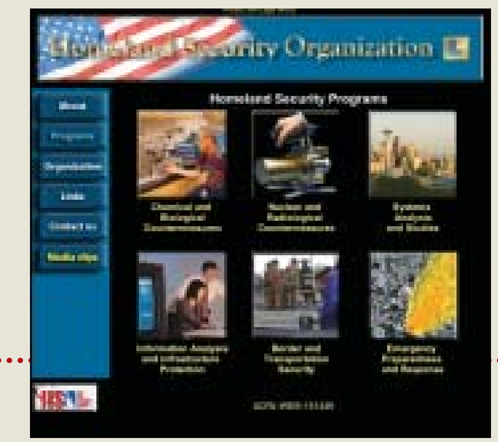
As a national security laboratory, Livermore is part of DOE's National Nuclear Security Administration (NNSA). The Laboratory's funding largely comes from the NNSA Office of Defense Programs for stockpile stewardship activities. Support for national security work also comes from the NNSA Office of Defense Nuclear Nonproliferation, various Department of Defense sponsors, and other federal agencies. Support from the Department of Homeland Security begins in 2003 with the transfer of program elements previously funded by DOE/NNSA to the new department.

As a multiprogram laboratory, Livermore's special capabilities are applied to meet important national needs. Activities include work for other DOE programs, principally Environmental Management and the Offices of Science, Civilian Radioactive Waste Management, Nuclear Energy, and Security and Emergency Operations. Non-DOE sponsors include federal agencies (such as the National Aeronautics and Space Administration, Nuclear Regulatory Commission, National Institutes of Health, and Environmental Protection Agency), State of California agencies, and industry.



Find Out More about Us

Visit the Laboratory's frequently updated Website at http://www.llnl.gov/ to learn more about our many scientific and technical programs. Discover the many opportunities for employment, academic research, and industrial partnerships. Read about our accomplishments each month in Science & Technology Review on the Web or in print.



Work performed under the auspices of the U.S. Department of Energy by the University of California, Lawrence Livermore National Laboratory under Contract W-7405-Eng-48.

U.S. Government Printing Office: 2003/583-060-70042

UCRL-AR-122705-02